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Sandia Systematic Declassification Review
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MK 21/26 34

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The Mk 17 weighed over 21 tons and consequently was difficult to transport and handle.

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It had a diameter of 60 inches and a length of 145 inches (both dimensions controlled by the size of existing aircraft bomb bays). and a weight of 20,000 pounds.[1]

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The committee proposed that if the test was successful, the device be weaponized, and assigned nomenclature of TX-21 to the program.[2,3]

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Sandia meanwhile had started scale studies of the TX-21 shape and, by early March 1954, had determined that it would require at least one spoiler band on the nose and another on the afterbody to produce adequate free-fall stability. It was thought that a flat area on the nose might eliminate the need for a nose band, and appropriate tests were scheduled. It was estimated that external dimensions could be definitely fixed by mid-1954; fuzing, firing and ballistic drop tests held in early 1955; design release effected in mid-1955; and early Mark production by January 1956.[5]

The weight of the bomb was discussed in the March 26, 1954 meeting of the TX-Theta Committee.

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This would allow the weapon to be delivered by the B-58 or Hustler bomber, then being designed. Los Alamos stated that any weight-reduction study would delay the overall program, and noted that bombers could refuel in the air after takeoff. There would thus be little difference in bomber range due to weapon weight.

After discussion, the Committee decided that an attempt would be made to trim the weight to 15,000 pounds. Sandia would test wind-tunnel models representing diameters between 48 and 54.5 inches, and would study the component space problems created by such diameters. It was requested that this investigation delay the program not more than one month.[6]

The military characteristics for a two-stage weapon in the 23,000-pound maximum weight class were released April 15, 1954.

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It was stated that more than one ballistic shape might be required for these various applications, but that the number of such shapes should be held to a minimum.

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The bomb was to be capable of being released either free fall or retarded as inflight-selectable options. Remotely controlled automatic nuclear arming and safing would be possible at any time prior to release of the bomb from the aircraft. A safe-separation time should be provided, and the weapon was to be able to provide either air burst or surface burst, with the latter feature acting as cleanup in the event of malfunction of the air-burst option. The burst height would be settable prior to flight. Any power source provided would have a storage life of from 2 to 5 years, require no preflight preparation beyond installation in the bomb, and no activation other than weapon release. The battery life after installation was to be at least equal to the time interval between normally scheduled inspections of the assembled bomb.[7]

It was felt that the TX-21 might have a diameter of 47.5 inches, a length of 147 inches in the parachute-retarded version, and would weigh between 15,000 and 16,000 pounds. The bomb would be compatible with the aircraft specified in the military characteristics.

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The parachute could be reefed for shorter times of fall. The air-burst fuze would be timer-armed and baro-fired.[8]

The results of wind-tunnel experiments now became available and were discussed in the April 23, 1954 meeting of the TX-Theta Committee. The tests had been made at a speed of Mach 0.93 on models with scale diameters of 48, 51, 52 and 54.44 inches. A quarter-caliber ogive nose had produced poor results. A hemispherical nose with a 0.4-caliber flat had resulted in fair dynamic stability with no spoiler bands, and good stability with one band located between Stations 77 and 103. Good pressure-sensing results had been secured, and more testing was scheduled.

Sandia noted that the ready-weapon philosophy adopted for the TX-15 would also be used for the TX-21. A sealed storage container would be provided and the weapon would be packaged in this container with fins attached and fuze installed. Most of the bomb would thus be assembled, and a minimum of strike assembly checks would be required during a ready-weapon life of 90 days.[9]

By the April 28, 1954 meeting of the Special Weapons Development Board, the diameter of the TX-21 had been increased to 52 inches, as it was desired to provide the largest weapon that could be carried by the B-47, the weapon's primary carrier.

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It was found that the P6M aircraft might subject the bomb to a vertical acceleration of 7.5 g's, and this might degrade the weapon's reliability. Additionally, the weapon fins would have to be relocated to allow the bomb to fit the rotating bomb-bay door of the P6M.[10] It was decided to concentrate on B-47 compatibility, and to consider application to other bombers at a later date.[11]

Additional discussion was held in the May 21, 1954 meeting of the TX-Theta Committee. Los Alamos was concerned that the weapon's efficiency might be sacrificed by an effort to reduce weight, and it was felt unwise to release any light design for stockpiling without proof tests

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Sandia noted that this change would require a new series of wind-tunnel tests. The final decision was to allow a weight increase, as the B-47 would have to refuel after takeoff with a 15,000 pound bomb, and the aircraft range would not be greatly affected by the heavier bomb weight.[12]

Scale model tests were conducted at the Cornell Wind Tunnel May 26-27, 1954, and discussed in the June 4, 1954 meeting of the TX-Theta Committee. Ten nose shapes had been tested, and the best results were obtained from a hemispherical nose with a half-caliber flat.

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The two weapons would have a near-contact burst as the primary option, achieved by a network of proximity fuzes, and these units would provide backup for the secondary air-burst option. The fuzing and firing systems in both options would be armed by a barometric switch. A true contact fuze for thermonuclear applications was being developed, but this design would require extensive testing.

Work was progressing on improved types of power sources, which would meet military requirements of minimum preparation time and long storage life; but nickel-cadmium batteries would be used in the early stockpiled weapons. A retarded trajectory was desired, due to the large yield of the weapon, and would be provided by a 24-foot-diameter parachute, reefed to provide a down-time of 75 seconds, as compared to an unreefed time-of-fall of 108 seconds. Use of this parachute would be controlled by equipment installed in the aircraft.

It was noted that the diameter of the bomb over the spoiler bands was 58.47 inches, the overall length was 148.37 inches, and the weight was 17,600 pounds.[20] The outer case was an aluminum-alloy shell which formed the main structural member of the bomb.

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The afterbody was a cylindrical extension of the warhead case, having the same diameter and being attached to it by an external bolting flange which also served as an aerodynamic spoiler band. Access doors were provided for battery installation, safety switch, and interconnecting box. All fuzing and firing components, with the exception of X-unit and pullout switch, were mounted on a plate readily accessible through the tail of the bomb after the parachute container was removed.

The bomb had four fins, with a 6- to 14-degree double-wedge shape, a 39-1/2-inch chord length, and an 80.9-inch span. The forward half of each fin was of sheet metal and the remainder of polyester-glass laminate. A proximity-fuze antenna was installed in the plastic portion of each fin.

Deployment of the 24-foot-diameter parachute could be selected at any time prior to weapon release. Fuzing and firing system components were the same as the TX-15 Bomb, with the exception of X-unit and cabling. A remote-setting baroswitch provided a detonation signal for air bursts, and a network of four proximity fuzes provided the signal for near-contact bursts, as well as cleanup for air-burst failures. Safe separation was provided by a baroswitch that was set prior to takeoff of the strike bomber.[21]

The Division of Military Application notified the Military Liaison Committee October 25, 1954, that the TX-21 would be design-released in March 1955, with stockpile entry in August 1955. To meet this schedule, it had been necessary to assign the highest priority to the development.

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Report SC3608(TR), Design and Description Report at Design Release of the Mk 21/26 Mod 0 Bomb, was reviewed in the June 1, 1955 meeting of the Special Weapons Development Board. The bomb was 58.48 inches in diameter over the spoiler bands, and 149.6 inches long. (b)(1), (b)(3) Either free-fall or parachute-retarded deliveries were possible. A 16-foot parachute furnished a 75-second time-of-fall.

The drop-test program was still under way, with nine ballistic and three fuzing and firing drops completed. Ballistic performance was satisfactory, but some parachute oscillations had been noted, and this problem was being solved as the test program progressed.

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This required an increased aircraft escape time of 100 seconds, and Wright Air Development Center was requested to develop a 24-foot-diameter parachute. It was felt that a two-stage deployment system would have to be used to mitigate the opening shock of the larger canopy.[33]

Report SC3694(TR), Engineering Evaluation of the Mk 21 Mod 0 Weapon, was presented to the December 14, 1955 meeting of the Special Weapons Development Board. Environmental resistance had been determined by component testing to performance standards, as well as overall weapon testing in arctic, tropic and desert environments. Models had been subjected to thermal tests; tests simulating loads involved in flights of B-47 and P6M aircraft; railroad humping tests; and rain, sand, dust, salt spray and sunshine tests. A total of 42 units had been drop-tested, including ballistic free-fall units, ballistic parachute units with proximity fuzes, ballistic parachute units with contact fuzes, and fuzing and firing units.

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Based on the testing program, it was believed that the weapon design imposed no operational limitations within the stockpile-to-target sequence and that the bomb met the military characteristics with the exception of the following: (1) The weapon weighed 17,500 pounds instead of the desired 15,000 pounds; (2) nickel-cadmium, rather than thermal, batteries were used; (3.

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and (4) the parachute design did not meet the military characteristics. Work was continuing in an effort to improve the last two points.

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Parachutes had to be inspected and repacked every 3 months, and drop aircraft were not to exceed a release velocity of 400 knots. On September 24, 1956, this release velocity was increased to 500 knots; and on July 12, 1957, a general release, with no limitations, was issued.[35, 36]

The sequence of events in the fuzing and firing sequence was as follows: ~~For the~~ For the air-burst option, either free-fall or parachute-retarded option could be selected. The arm baroswitch was set at the desired arming altitude prior to takeoff of the bomber. During flight to the target area, power was applied to the battery heaters, the firing baroswitch was set to the selected altitude, the nuclear capsule was remotely inserted, and the safing switch was armed.

When the bomb was released, withdrawal of the arming wires closed the pullout switch and supplied power to the fuze. The inverters started operation and, after the safe-separation interval (determined by the setting of the arm baroswitch), the X-unit started to charge and the proximity fuzes were armed. A 3-second delay was provided by a timing device to prevent firing before the X-unit attained its normal charge.

As the bomb reached the desired burst altitude, the firing baroswitch closed, actuating the firing switch in the X-unit, discharging the capacitor bank into the detonator bridge wires, and initiating the explosive and nuclear sequence. If the system malfunctioned, the proximity fuze detonated the bomb. The parachute was deployed after release from the aircraft, if the retarded option had been selected. If a near-surface burst was selected, the barometric fuze was set at -3000 feet and the proximity fuze detonated the weapon.

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The Mk 21 Mod 0 first appeared in stockpile December 1955, and final deliveries were made in July 1956.

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The TX-26 was never authorized for production.[38]

Meanwhile, work had been proceeding on the design of a true contact fuze.[39] Report SC3606(TR), Proposed Electrical Characteristics for the Fuzing and Warhead Systems for the TX-15-X1 and the TX-21/26-X1 Weapons, was presented to the April 27, 1955 meeting of the Special Weapons Development Board.

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Four methods of producing contact bursts had been considered. The first was the use of nose probes, both fixed and extendible. Study showed that this system was not ideal, since much of the weapon was left insensitive to impact. A second possibility was the use of an insulated double shell, which would crush on contact and produce a firing signal. This was a one-shot type of device, and was very sensitive to antiaircraft fire. A third method was the use of low-burst (1- to 25-foot) proximity fuzes, but these required further development. The fourth was use of barium titanate crystals, and appeared the most promising.

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The contact fuze was discussed in the June 1, 1955 meeting of the Special Weapons Development Board when Report SC3607(TR), Proposed Ordnance Characteristics for the TX-21/26-X1 Weapon, was presented. The report noted that four contact crystals would be mounted on the nose of the bomb and a fast-firing X-unit installed. The modified design would be released in February 1956 and Mark units produced by late 1956.[32]

During the development drop program of the TX-21-X1, data were obtained that caused concern over the operation of the contact crystal fuzing network.

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A joint letter from Sandia and Los Alamos was forwarded to the Santa Fe Operations Office June 19, 1956. This noted that the possibility of providing a boosted, externally initiated primary had been studied.

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Field Command notified Albuquerque Operations November 1, 1956, that the Mk 21 handling equipment caused spalling of concrete floors in storage igloos. This was due to the hard casters of the weapon bolster, and development of a suitable wishbone trailer was requested.[46] Sandia subsequently designed and produced a prototype device incorporating rubber tires.[47]

All Mk 21 Bombs were withdrawn from stockpile in the period June through November 1957, and were converted into Mk 36Y1 Mod 1's.[38]

(b)(1), (b)(3)

TX-22 Cross-Section

Timetable of TX-22 Events

9/18/53 (b)(1), (b)(3)

10/29/53 Santa Fe Operations Office authorizes Sandia to assist in the above design.

2/2/54

(b)(1), (b)(3)

4/30/54

TX-22

(b)(1), (b)(3)

Sandia was requested to develop preliminary ballistic configurations, as well as requisite parachute ~~and~~ and fuzing and firing components.[48]

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The Santa Fe Operations Office requested Sandia, October 29, 1953, to assist the Radiation Laboratory in work on the aerodynamic case. Sandia would also design the fuzing and firing system, and conduct flight tests for both ballistics and systems prove-out.[49]

A review of a prospective drop-test program was held November 19, 1953. The devices *would be released from a B-36 bomber flying at an altitude of 40,000 feet.*

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The question of parachute retardation was raised, and was subsequently referred to the Air Force Special Weapons Center. (b)(1), (b)(3)

(b)(1), (b)(3)

However, the Santa Fe Operations Office, in a letter dated March 17, 1954, stated that any ballistic or fuzing and firing work on this design would be of minimal value, since the weaponized version would probably differ greatly from the test device. It was suggested that plans be made to hold the test on a barge, thus obviating the need for case design.[57]

(b)(1), (b)(3)

Timetable of Mk 36 Events

11/22/55	(b)(1), (b)(3)
1/3/56	TX-36-X1 design released.
4/56	Mk 36 Mod 0 enters stockpile.
5/56	Mk 21/36 Mod 1 Bomb design released.
7/13/56	TX-36-X2 program authorized for development.
9/24/56	(b)(1), (b)(3)
10/24/56	Proposed ordnance characteristics of TX-36-X2 Bomb reviewed by Special Weapons Development Board.
10/56	Mk 21/36 Mod 1 Bomb enters stockpile.
11/15/56	(b)(1), (b)(3)
4/12/57	TX-36-X2 program suspended.
4/22/57	(b)(1), (b)(3)
7/11/57	Resumption of work on TX-36-X2 authorized.
7/57	(b)(1), (b)(3)
4/23/58	TX-36-X2 design released.
1/9/59	Albuquerque Operations Office cancels Mk 36 program~~s~~.

Mk 36

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The TX-21-X1 program was subsequently canceled, but the TX-36-X1 was design-released January 3, 1956, and became, in production, the Mk 36 Mod 0.[63, 64] The weapon entered stockpile in April 1956 with a proximity fuze and internal initiator.[38]

Meanwhile, other improvements in the Mk 21 design had been suggested, principally in the fuzing and firing system. This work had begun in early 1955 in connection with the Mk 15 and Mk 39 programs, and the proposed design would provide options of either air burst or true contact firing. The weapon would be armed and fired by barometric switches, and the contact crystals would act either as primary fuze or as backup to the air-burst system. Thermal batteries would replace the nickel-cadmium units and would supply both low-voltage power for the fuzing system and high-voltage power for charging the X-unit.

Report SC3826(TR), Design and Description Report at Design Release of the Mk 21/36 Mod 1 Bomb, was released May 1956. This noted that the yield, weight, and physical configuration of the Mod 1 was essentially identical with the Mod 0, with the exception of the fuzing and firing system. The Mod 1 would be employed in a high-altitude level release, using either a free-fall or retarded trajectory.

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Baroswitch settings were made on the ground prior to aircraft takeoff by a single dial setting. This setting was computed by comparing the intended height of burst with the target elevation above sea level and including a 300-foot offset correction. Prior to bomb release from the strike aircraft, the selector switch was placed at either air- or ground-burst position, the nuclear capsule inserted, the safing switch placed in the armed position, and the option switch placed at either the open or closed position, depending on whether ground or air burst had been selected.

The release of the bomb from the aircraft closed a pullout switch in the high-voltage-battery firing circuits, and operated magneto generators which furnished electrical pulses to ignite the low-voltage batteries. Power from these batteries was applied to the open contacts of the arm baroswitch. When the arm baroswitch closed, at the appropriate point in the weapon trajectory, low-voltage power was applied through the closed pullout switch and safing switch to the activating circuits of the high-voltage batteries, placing these latter devices in operating condition. The 2500 volts provided by these batteries charged the X-unit and supplied plate voltage to the trigger circuit.

If air-burst option had been selected, closure of the firing baroswitch applied a signal from the low-voltage batteries to the trigger circuit, thus detonating the bomb. If ground-burst option had been selected, the option switch held the firing circuit open, allowing the weapon to fall to the ground, where the contact fuze supplied the detonation signal.[65]

The Mk 21 Mod 1 Bomb was never produced, but the Mk 36 Mod 1 design entered stockpile in October 1956.

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(b)(1), (b)(3)

/The TX-36-X2 would be design-released in June 1957 with early production scheduled for July 1958 and operational availability in the fall of 1958.[69]

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(b)(1), (b)(3) Albuquerque Operations Office replied February 13, 1957, noting that Sandia and Los Alamos would issue a joint reply after TX Committee meeting of February 21, 1957.

(b)(3)

The Division of Military Application replied that these rates could not be currently established, as no production directive had been released.

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Subsequently, April 12, 1957, all activity on the TX-36-X2 program was suspended by the Albuquerque Operations Office, based on an expectation that the program would be canceled.[76]

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Sandia was requested to prepare a product definition as soon as possible.[77]

Sandia wrote to the Albuquerque Operations Office May 3, 1957, proposing that nomenclature for the Mk 36 Mod 1 Bomb include the designations Y1 and Y2.[78]

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The foregoing was forwarded to the Division of Military Application February 17, 1958, with a production recommendation. It was noted that the design would provide safety features that had been suggested by the Air Force Special Weapons Center and that the modification could be completed by September 1959.[85]

The Division of Military Application sent a teletype to the Albuquerque Operations Office April 10, 1958, authorizing modification of some Mk 36 Mod 1/Y1 and Y2 Bombs to the TX 36-X3 configuration.[86] This program had been approved by the Military Liaison Committee, which agreed that weapon safety would be thereby materially increased.[87]

Report SC4146(TR), Description and Status at Complete Design Release of the TX-36Y1-X2 Bomb, was presented to the April 23, 1958, meeting of the Special Weapons Development Board and subsequently released in May 1958.

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The design had been authorized for development July 13, 1956, suspended April 12, 1957, and work resumed July 11, 1957.

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A new fuzing and firing system was provided, but the contact fuze was retained.

(b)(3)

(b)(3)

Report SC4222(TR), Final Evaluation of the Mk 36Y2 Mod 1 Bomb, was presented to the December 17, 1958, meeting of the Special Weapons Development Board.

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(b)(1), (b)(3)

Dynamic drop tests to ultimate loads, railroad humping tests, extreme temperature tests, and a simulated 6-month tropic storage test had been conducted, and these demonstrated the ability of the weapon to withstand these environments.[89]

At the above Board meeting, Report SC4188(TR), Final Evaluation of the Mk 36Y1 Mod 2 Bomb, was also presented.

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About half the existing stockpile of Mk 36Y1 Mod 1 Bombs would be converted to this new design, which had been called in development the TX-36-X2.

(b)(3)

The program included environmental, drop and neutron-generator compatibility tests, and demonstrated that the weapon was more than adequate to withstand the stockpile-to-target sequence. Both land and water targets had been included in the drop-test program, with release altitudes between 20,000 and 50,000 feet.[89]

On January 9, 1959, Albuquerque Operations Office canceled the Mk 36 program. The Mk 36 Mod 1 Bombs scheduled for updating would remain in current status until retirement in mid-1959.[90] This retirement program was later deferred to mid-1961.

Glossary of Terms

Air Force Special Weapons Center -- That element of the Air Force Systems Command having to do with compatibility testing of nuclear devices with aircraft. Located at Kirtland Air Force Base, Albuquerque, New Mexico.

Albuquerque Operations Office -- The local office of the Atomic Energy Commission (AEC) concerned with the operations of Sandia Corporation.

Armed Forces Special Weapons Project -- An interdepartmental agency formed to handle military functions related to atomic weapons.

Arming -- The act of arming a weapon; that is, preparing it for firing.

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Division of Military Application -- An AEC office that functions as liaison between the Military and weapons designers and producers.

Thermal Battery -- A battery whose electrolyte is in a solid state while inactive. To activate, heat is applied to this electrolyte, melting it and putting the battery into active output condition.

Thermonuclear -- Two-stage reaction, with a fission device exploding and starting a fusion reaction in light elements.

Tritium -- The hydrogen isotope of mass number 3.

Two-Stage -- Combination of fission and fusion action in a weapon.

TX Committee -- A joint committee of Los Alamos and Sandia members, established to guide the development of implosion-type weapons.

TX-Theta Committee -- A committee established to guide the development of thermonuclear weapons.

University of California Radiation Laboratory -- A laboratory established under the guidance of the University of California to work on thermonuclear designs, and located at Livermore, California.

Uranium-235 -- A radioactive element, an isotope of uranium-238.

Uranium-238 -- A radioactive element, atomic number 92. Natural uranium contains about 99.3-percent uranium-238; the rest is uranium-235.

X-Unit -- ~~A high-voltage transformer.~~ A device used to provide high voltage to the weapon detonators.

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77. SRD TWX, Albuquerque Operations Office to Sandia Corporation, dtd 4/24/57. AEC Files, MRA-5, Mk 36, 2/57.

78. SRD Ltr, RS 1000/3131, Sandia Corporation to Albuquerque Operations Office, dtd 5/3/57, subject, Nomenclature, Mk 36 Mod 1 Bomb. SC Central Technical Files, Mk 36, 1957.

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81. SRD Ltr, RS 1/1037, Sandia Corporation to Albuquerque Operations Office, dtd 8/8/57, subject, Development and Production Activities for the TX-36-X2. AEC Files, MRA-5, Mk 36, 2/57.

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83. SRD Ltr, RS 1260/127, Department 1260 to Department 1210, SC, dtd 11/25/57, subject, Recommended Product Change Proposal for Mk 36 Mod 1 Weapon. SC Central Technical Files, Mk 36, 1957.

84. SRD Ltr, RS 1/1076, Sandia Corporation to Albuquerque Operations Office, dtd 1/22/58, subject, Incorporation of the High-Voltage Safing Switch in the Mk 36 Mod 1 Weapon. SC Central Technical Files, M-36, January-June 1958.

85. SRD Ltr, RS 3466/81922, Albuquerque Operations Office to Division of Military Application, dtd 2/17/58, subject, Request for TX-36-X3 Program Authorization. SC Central Technical Files, TX-36, 1956-9.

86. SRD TWX, Division of Military Application to Albuquerque Operations Office, dtd 4/10/58. AEC Files, MRA-9, TX-36, 3/58.

87. SRD Ltr, Division of Military Application to Albuquerque Operations Office, dtd 4/11/58, subject, TX-36-X3 Program. AEC Files, MRA-9, TX-36, 3/58.

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89. TSRD Minutes, RS XLIII-4195, Special Weapons Development Board to Distribution, dtd 12/17/58, subject, Minutes of 118th Meeting. SC Files.

90. CRD TWX, Albuquerque Operations Office to Distribution, dtd 1/9/59. SC Archives, TX-21/36, 1955-7.

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